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PRESENT STATUS OF THE ALFALFA WEEVIL PROBLEM WITH PARTICULAR REFERENCE TO QUARANTINES

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INTRODUCTION

The alfalfa weevil has been the subject of many discussions and of frequent controversy with regard to its destructiveness and abundance in its present area of distribution, as well as to the benefit or harm attributable to certain quarantine procedures associated with its control.

It is not the purpose of the present discussion to enter into the controversy on the merits or demerits of the weevil quarantines in particular or in general, but rather to present as complete a picture of the economic status of the weevil as available information will permit, and to furnish a brief review of some of the information bearing on quarantines which has been accumulated through research by the Bureau of Entomology and Plant Quarantine over a period of 25 years. But little information on the means of spread of the weevil is available, in addition to that already published in technical journals and reports. It may be of some value, however, to bring together such information as has particular bearing on the quarantine problem and to indicate results obtained in work accomplished by this Bureau but not previously reported.

DISTRIBUTION AND ABUNDANCE OF THE WEEVIL

No regular, extensive surveys of weevil distribution or abundance in the infested areas have been conducted in recent years. Surveys to determine weevil abundance have usually been limited to those districts known to have experienced damage at fairly regular intervals. The earlier surveys consisted mostly of observations on the prevalence of injury, supplemented by sweepings made in occasional fields to determine the larval population. Most of such work was done in Utah. Estimates of the abundance of adult weevils in the fall of the year began in 1932, with the sampling of fields in 10 districts scattered throughout the weevil territory. In this first fall survey, some 12 to 15 tons of samples were washed and examined. The information thus obtained is serviceable both in indicating threatened damage and in providing a reliable record of the abundance of the weevil and its parasites from year to year.

In 1935 a somewhat extensive survey of distribution was conducted, in cooperation with a number of States, particularly in those areas contiguous to known infestations. In a few cases areas were examined that were known to have been infested but where weevils had not been reported for many years and where determination of present occurrence was of particular interest.

This survey added to the known infested area Wayne and Kane Counties in Utah, Coconino County in Arizona, Montezuma County in Colorado, Clark County in Nevada, and Scotts Bluff County in Nebraska, and confirmed the presence of the weevil in Union and Baker Counties, Oregon, and in Sioux County, Nebraska. The present known area of distribution is indicated on the map (figure 1). This includes those records reported by State agencies and by the Salt Lake City laboratory of the Bureau of Entomology and Plant Quarantine. It does not agree in some respects with the map presented by Essig and Michelbacher in 1933, in their paper on the alfalfa weevil,[1]

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[1] Essig, E.O., and Michelbacher, A.E., The Alfalfa Weevil. Calif. Agr. Expt. Sta. Bul. 567. 1933.

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in that Harney County, Oregon, and Sublette and Teton Counties, Wyoming, are indicated as uninfested, and in that additional records obtained since 1933 have been added. If authentic records of the infestation in Harney, Teton, and Sublette Counties are available they have escaped the writer's search. Attention is directed to the fact that in this map the county is used almost exclusively as a unit of infestation. It should not be inferred from this that all of each county indicated as infested is entirely infested. The weevil has been unreported recently in a number of the counties shown in the map as infested.

EXTENT OF DAMAGE RESULTING FROM THE ALFALFA WEEVIL

As with most insects, weevil damage is hard to estimate accurately. That losses were extremely heavy in certain areas soon after establishment and that the weevil continues to cause heavy commercial losses in certain restricted areas cannot be doubted. It is also true, however, that considerable portions of the infested area have never suffered much commercial damage and that losses may now be so slight as to be relatively insignificant in some of the areas where serious injury was recorded in the early stages of the infestation.

The present reduction in annual loss experienced in some of the districts longest infested, as compared with the earlier losses, when the entire first crop was destroyed over considerable areas, is reasonably well explained by the recent adoption of improved cultural practices, such as maintenance of more vigorous stands, earlier cuttings, and timely irrigation. To these must be added the benefits conferred by the establishment of the introduced hymenopterous parasite Bathyplectes curculionis Thoms., and possibly by the intervention at harvest time of climatic conditions that were less favorable to the weevil.

On the map (fig. 1) an attempt has been made to classify the infested area into three categories according to frequency of damage to the alfalfa crop. This classification is based on data furnished by J. C. Hamlin and G. I. Reeves, of Salt Lake City, and on information obtained directly from State agencies. The classification into areas of frequent, occasional, and rare damage is more or less arbitrary but it represents the best information available. It may be noted that frequent damage has been limited to two States--Utah and Nevada. It is probable that portions of western

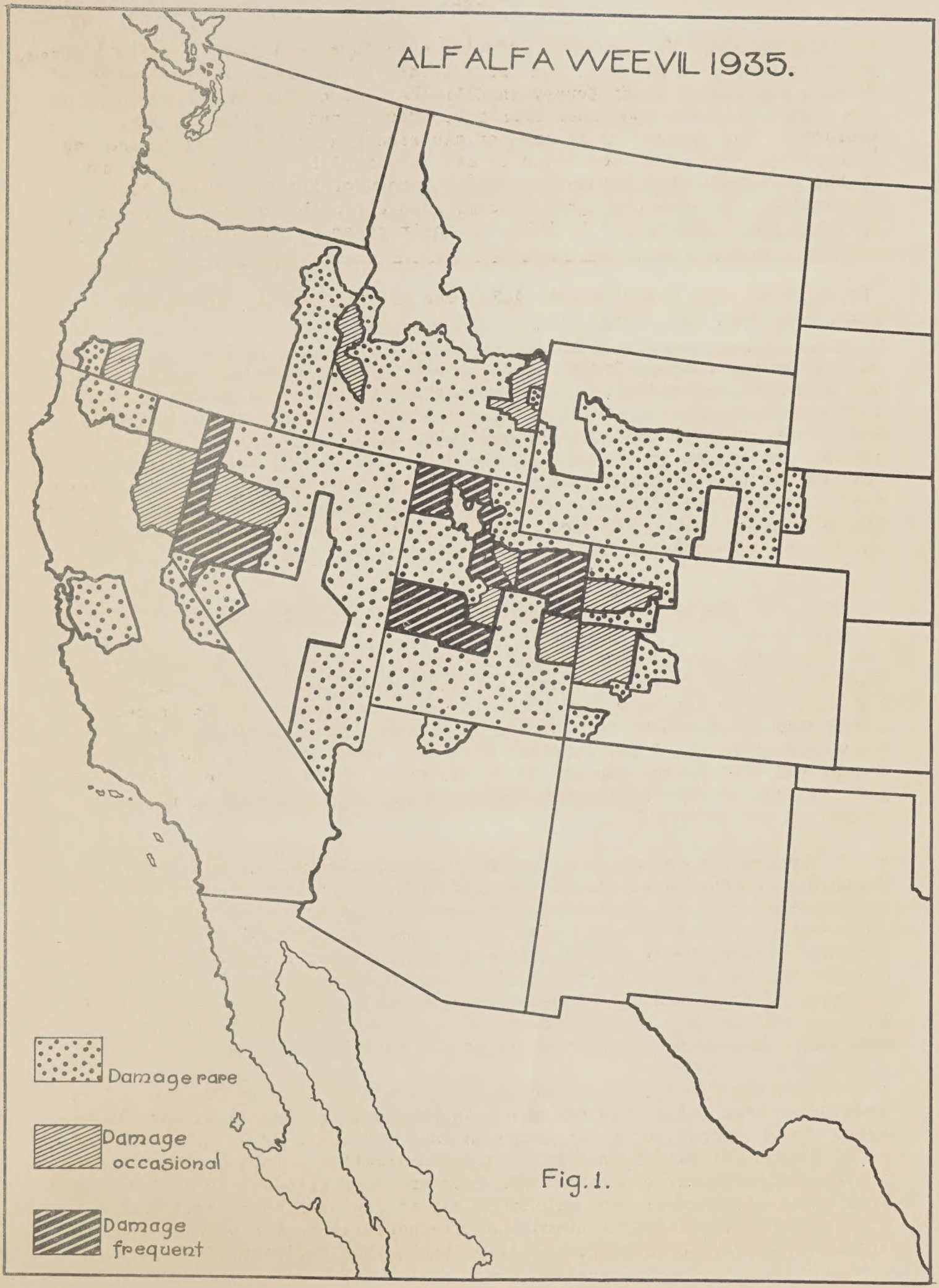

ALFALFA WEEVIL 1935.
Damage rare
Damage occasional
Damage frequent

Fig. 1.

Colorado might well be included in this category as well as a few other areas shown on the map as areas of occasional damage. In some of the rarely damaged areas commercial loss has never been experienced.

Considering the rather extensive region in which the weevil now does little or no damage, the important loss of extra-State hay markets, due to the enforcement of quarantines, must be considered as chargeable to the alfalfa weevil, and in some of the areas under consideration this is the major loss resulting from weevil infestation.

Last fall a request was made of some of the entomologists in the infested States that they furnish an estimate of the losses caused by the weevil in 1935, and the losses from this cause that occurred in their respective States over a previous 10-year period. Not all replied and some of the replies received are not complete, but the information thus obtained has been combined with other available data to comprise an estimate indicative of the importance of this insect as a pest, exclusive of any loss attributable to interference with alfalfa markets, due to the enforcement of quarantines. (Table 1.)

Table 1.--Losses from the alfalfa weevil

State	Losses during Past 10 Years	Loss In 1935
California		
Central California	Practically none.	Severe damage to first crop in 4 fields.
Lassen County----	Average 2 1/2 per cent of crop.	Slight damage.
Colorado----------	$25,000 to $160,000 per year. Always noticeable injury on first crop in valley sections. Sometimes as high as 40 per cent of first crop in Delta and and Montrose Counties.	Delta County, 25 per cent of first crop, $40,000; Montrose County, 25 per cent of first crop, $20,000; Mesa County, Grand Junction Section, 50 per cent of first crop, $100,000. Also retardation of second crop.
Idaho----------	Practically none in southern and southwestern Idaho. Moderate injury in upper Snake River Valley where soil fertility is low. Annual loss to Grimm alfalfa growers in eastern Idaho $5,000 per year.	Moderate damage in Canyon, Ada, Payette and Washington Counties, slight damage in Adams County, slight damage in eastern Idaho.

Table 1.--Losses from the alfalfa weevil
(Continued)

State	Losses During Past 10 Years	Loss in 1935
Nebraska	None (except for 1935).	Slight damage to a few fields in Sioux County.
Nevada	No figures available. Considerable damage in western counties.	Low damage.
Oregon	Very slight, except in Jackson County, where loss has been moderately heavy recently.	33 1/3 per cent on first and second crops in Jackson County. Approximate loss, $100,000.
Utah	Annual loss to hay conservatively 5 per cent of annual production, or 60,000 tons valued at $600,000; 5 per cent loss to seed crop.	Approached 10-year average. Severe damage in Box Elder, Salt Lake, Utah, Duchesne, Sevier, and Sanpete Counties.
Wyoming	Slight.	Negligible.

DISSEMINATION THROUGH COMMERCE IN AGRICULTURAL PRODUCE

Before reviewing the information available on the artificial transportation of alfalfa weevils in agricultural produce, it will be interesting to tabulate the commodities suspected of being most important in this regard, as indicated by the quarantines maintained by 25 States against the alfalfa weevil. The information given in table 2 has been provided by the Division of Domestic Plant Quarantines of the Bureau of Entomology and Plant Quarantine from the most recent information available in that office.

Table 2.--Commodities included in quarantines of 25 States against the alfalfa weevil.

Commodity	Number of States maintaining quarantine	Provisions of quarantine	
All kinds of hay and cereal straw	25	Prohibited	23
		Prohibited in part and restricted in part	1
		Restricted	1
Alfalfa meal	22	Restricted, approval of mills or permit required	15
		Prohibited in summer, restricted in winter	2
		Prohibited in part, restricted in part	1
		Prohibited, except as directed	4
Chopped hay	25	Included in hay restrictions	19
		Prohibited in summer, restricted in winter	5
		Restricted all year	1
Alfalfa seed	4	Prohibited	1
		Restricted	3
Salt-grass packing	8	Restricted only	8
Nursery stock	3	Fumigation required	3
Greenhouse plants	2	Fumigation required	2
Potatoes	8	Require screening	7
		require certification as free	1
Used machinery	6	Restricted movement	6
Railway cars	7	Restricted movement	7
Emigrant movables	3	Restricted movement	3

A large amount of work was done during the early years of investigation of the alfalfa weevil to determine what commodities may be responsible for weevil distribution. More recent work, which has been reported elsewhere, was done on railway cars, alfalfa meal, and baled hay as mediums for the movement of this insect. The work on dissemination of weevils with commodities is herein reviewed only in sufficient detail to indicate the extent and present state of our information on the importance of the transportation of various commodities in weevil spread.

Fruits and Vegetables.

Most of the work of the Bureau of Entomology and Plant Quarantine specifically aimed at determining the importance of the movement of fruits and vegetables in transporting the weevil was done in the early days of the weevil quarantines, although observations incidental to other work have been made almost continuously. In 1913, from July until October 1, one entomologist was employed at Brigham, and other localities in Utah, one at Pocatello, Idaho, one at Helena and Butte, Montana, and one at Rock Springs, Wyo., and Denver, Colo., constantly observing the handling of produce at all stages, from its harvest in the fields in the infested area to its delivery to the consumer. Examinations were made of fields, orchards, packing houses, freight and express shipments, and freight, express, and passenger cars, at the Utah point of origin, in transit, and at the destination points in Idaho, Montana, Wyoming, and Colorado, mentioned above. During the period of this project the weevils were active throughout the infested territory and conditions were at the best for finding them on fruits and vegetables.

These observations were very extensive and included examination by S. J. Snow, at Brigham, Utah, and other Utah shipping points, of hundreds of cases of apples, apricots, peaches, plums, cherries, strawberries, raspberries, blueberries, corn, cucumbers, beans, and other vegetables. No weevils were actually found on the commodity at the shipping point, although one weevil was found in a case of apricots in transit to Sugar City, Idaho, and one in cherries in transit to Dillon, Mont. S. J. Snow and T. R. Chamberlin examined 10 cars of potatoes at Ogden, Utah, and discovered a total of 26 weevils. Desla Bennion examined 50 cars of fruits and vegetables at Pocatello, Idaho, and numerous shipments of potatoes, but found no weevils. C. W. Creel examined numerous cases of apricots, cucumbers, beans, plums, and cabbages at Butte, Mont., and found no weevils in them, but discovered a total of 51 weevils in 7 carloads of potatoes. At Rock Springs, Wyo., C. W. Creel examined hundreds of cases of fruits and vegetables without finding any weevils but found 20 weevils in 2 carloads of potatoes. P. B. Miles, at Denver, Colo., examined 67 carloads of prunes, pears, mixed fruit, peaches, and apples and found no weevils, but he found 7 weevils in 3 cars out of 67 carloads of potatoes examined. Mr. Miles traced the cargoes of these cars as they were unloaded at Denver and examined them in the commission houses. He met practically all of the trains that carried express and examined individual packages containing produce from Utah points. All of the weevils found at Denver in the course of the two months, covering the most active season, were 7 living and 7 dead weevils--all in potato shipments.

During July T. R. Chamberlin was assigned to examine produce wagons at the Salt Lake City market. These examinations included large quantities of raspberries, alfalfa seed, tomatoes, potatoes, turnips, onions, corn, cauliflower, beets, melons, cherries, radishes, carrots, cucumbers, and a variety of other truck crops and fruits. No weevils were found at the market, even on potatoes. Weevils were found on potatoes at the Ogden market, however, apparently as a result of the handling of potatoes with alfalfa hay, a practice common in that area but not followed in the Salt Lake City market.

The detailed investigations of 1913, together with more or less continuous observations over a period of 10 years, have been the basis for the conclusion that the transportation of the various commodities listed--with the possible exception of potatoes, for which screening is required by a number of the state quarantines--is of little or no importance in weevil dissemination. It is probable that much of the infestation in potatoes was the result of hauling them in wagons cushioned with alfalfa hay and with a few forkfuls of hay carried on top of the load as feed for the team. The extensive use of auto trucks and the improvement of roads has now undoubtedly changed this practice to a large extent.

Alfalfa Hay in Stacks

It has been adequately demonstrated, by observations extending over a period of years, that weevils may occur in stacked alfalfa hay, and that the numbers are dependent (1) on the intensity of the field infestation, (2) on the amount of handling between the harvesting in the field and the time of examination; and (3) on the lapse of time between the stacking and the date of examination. A detailed examination of 15 stacks by Chamberlin, Miles, and Snow, in 1913-14, indicated that in first-cutting stacks weevils may survive in the stack proper as late as January 13 and around its base as late as March 14, and in stacks containing second or third cuttings, as late as April 7, both in the stack and around its base. Similar results were obtained by Hamlin, Hawley, and others in 1927 and 1928, when it was determined that weevils may survive in excess of 111 days in stacks of second cuttings. It must be recognized, however, that, although weevils can be recovered in stacks, the numbers present are small and the mortality extremely high. In view of these findings alfalfa hay must be considered as infested material, because no one can be sure that the stacks are absolutely free of weevils where the hay is produced in an infested field.

Baled Hay

That weevils occur normally in hay baled from the stack has been inferred from their occurrence in stacks and from their discovery in railway cars that have contained baled hay. The only detailed work by the Bureau of Entomology and Plant Quarantine on the effect of baling on weevil survival and longevity in baled hay has been reported by Larrimer and Reeves in the Journal of Economic Entomology for June 1929 and by Hawley in California State Department of Agriculture Special Publication 115 (1932). In this work the effect of the baling process upon the alfalfa

weevil was tested and a determination made of the longevity of weevils in baled hay. This hay was baled on September 22, 1927, from a stack of the same year's production. During the baling process 1,000 weevils were introduced into each of three bales--a number enormously in excess of that which would occur normally. The essential results of this experiment are (1) that at least 39 per cent of the weevils were injured during the baling process, (2) that living weevils were readily found for a period of 60 days in one bale broken open 4 days after baling, (3) that live weevils emerged for at least 39 days after baling, and (4) that on February 15 no live weevil was found inside a bale that had remained unbroken for 146 days after baling.

The results of these limited observations indicate that a few weevils may live in baled hay, under late fall and early winter temperatures for over 2 months, but that all die in less than 5 months after baling. When it is considered that these results were obtained under conditions of extremely high infestation, the danger of transporting weevils in baled hay, if it is baled early in the winter and held for 4 or 5 months for shipment, would seem to be slight. This is particularly evident when the normal infestation of box cars, as discussed later, is taken into account. It would not be possible, however, to state that such hay would be absolutely free from weevils, and the small number of recorded observations will not permit the definite statement that under some conditions of storage weevils will not survive more than 5 months in baled hay.

Alfalfa Seed

The observations of Titus, Parks, and Henderson on the absence of infestation in alfalfa seed is corroborated by the results of observations over a period of years made by the Bureau laboratory at Salt Lake City.

Alfalfa Meal

The work of the Bureau on the liability of transportation of alfalfa weevils in alfalfa meal was reviewed by Larrimer and Reeves in June 1929, and by Reeves, Hawley, Hamlin, and others, in 1932, in the publications previously referred to. The examinations reported in these publications were of the larger stationary mills. On the basis of careful experimentation this work established the fact that few weevils reached the mill premises and that those which did were so located that they constituted little menace to recontamination of the meal prior to shipment; and, further, that this slight chance could be eliminated by the erection of screened runways between the sacker and the car, or by blowing the meal directly into the car. It also established the fact that the mills under investigation produced weevil-free meal.

Subsequent work, which has not been reported, was conducted by G. I. Reeves and J. C. Hamlin, at Medford, Oregon, in 1930, to determine the insecticidal action of three different makes of small, portable meal mills. The results of these investigations indicate that not all portable mills produced weevil-free hay, even with fans operating at a speed of 3,000 revolutions per minute. This work on portable mills also indicated that,

so far as these mills are concerned, the insecticidal action cannot be expressed solely in terms of speed of the fan but that other features of the mechanical design may be more important. The results of tests of the insecticidal action of portable meal mills are given in table 3.

Table 3.--Tests of insecticidal action of portable alfalfa meal mills

Make of machine	Approx. speed	Weevils used	Screen	Survival		Whole dead weevils	Meal texture
	R.p.m.	Number	Inch	Number	P.ct.	Number	
A	3,000	200	3/4	8	4.0	2	Variable; pieces 4 inches long
A	3,000	200	1/2	9	4.5	4	Finer; variable
A	3,000	300	1/4	4	1.3	3	Fine
B	2,000-2,400	200	1/2	0	0	0	Medium; uniform
C	2,250	300	7/16	0	0	2	Medium; uniform
C	2,250	300	1/4	0	0	0	Fine; uniform

The insects escaping the action of these mills may be of little practical importance in view of the frequent contamination of the freight cars into which the hay is loaded--cars that are used also in the transportation of other commodities.

Cereal Straw

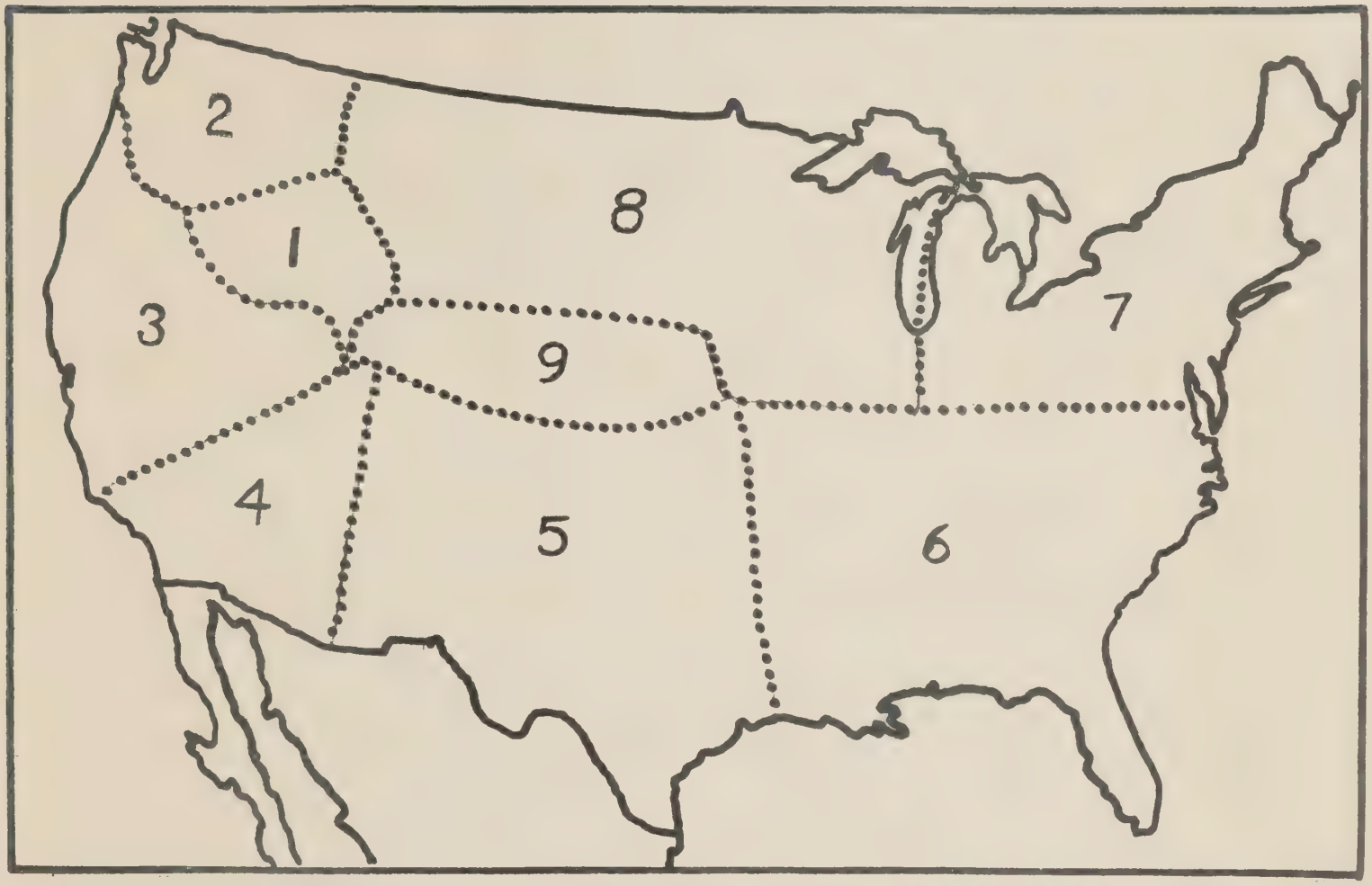
No detailed information is available on the infestation of cereal straw or of its possible importance in weevil transportation, nor would it seem feasible to obtain sufficiently detailed information to determine beyond doubt that such straw is absolutely free of weevils. It is known, however, that weevils do not normally feed on cereals, and such contamination as might possibly occur would necessarily be due to the production of the straw in close proximity to alfalfa fields or other sources of contamination, or the utilization of straw from fields in which the cereal is used as a cover crop for alfalfa. The baling of straw in balers previously used for alfalfa is also a conceivable source of contamination. So far as present information goes, weevils have never been taken in straw that was uncontaminated by alfalfa, and the available facts suggest the possibility of permitting its shipment under certificate or other safeguard.

Railway Cars

In 1913, in connection with the detailed study of the transportation of weevils in various agricultural produce, extensive observations were made of railway cars to determine, if possible, the danger of transporting weevils in or on cars in transit. S. J. Snow examined the outside of 230 freight cars placed at different times on side tracks at Brigham, Utah. He also examined rather thoroughly the inside of 23 box and baggage cars, and the outsides of the cars of 18 trains that stopped temporarily at the depot. No living weevils were discovered. Desla Bennion, at Pocatello, Idaho, examined the outsides of 56 freight cars, the outsides of the cars of 37 through-passenger trains coming from the weevil-infested territory, and the insides of the baggage and express cars on most of these trains, without discovering any weevils. C. W. Creel, at Butte, Mont., examined the contents of 24 baggage and express cars, inspecting their interiors, especially the floors, besides examining the outsides of through trains, the interiors of passenger coaches, and the sides and top of coal, coke, and other freight cars, without discovering weevils. These examinations, however, were of necessity more or less cursory, and weevils have been reported by other investigators on passenger cars, notably in 1910 by Titus, who observed that it was not uncommon to find weevils in the cars of railway trains, and who reported the definite finding of a number of weevils in the vestibule of one sleeping car in Salt Lake County, Utah.

The most significant evidence of the importance of railway cars in transporting weevils is found in the result of investigations, conducted in 1928 by the Salt Lake City laboratory, on weevils occurring in empty hay cars. This work was reported in 1929 by Larrimer and Reeves in the Journal of Economic Entomology for June, and in 1932 by Reeves, Hawley, Hamlin, and others, in California State Department of Agriculture Special Publication 115. A total of 130 empty hay cars were examined during June, July, August, September, and November. Living weevils were found in nearly 40 per cent of the cars that carried hay baled from the stack, while of those that hauled hay baled in the field from the cock nearly 55 per cent were infested. Of all the cars examined, 40.5 per cent carried the alfalfa weevils. As these examinations were limited to an examination of only a fraction of the chaff on the floor, many of the cars listed as uninfested undoubtedly carried weevils. Sixty-six weevils were found in one car examined. Additional investigation of the movement of these cars indicated that, during a 60-day period following the original examination, only 11.5 per cent remained within the region for a 60-day period. The remaining 115 cars traveled as indicated in figure 2 in an average of 3 out of a possible 9 regions. One of the traced cars traveled over the lines operated by 14 different railroads. Within 15 days after the examination was made at Ogden, every one of 9 regions of the United States was visited by one or more of the cars.

In 1929 additional work was conducted with three cars to determine more accurately the length of time weevils would remain in empty railroad cars that contained chaff. Details of this work have not been published. Each car was prepared by covering the floor about 1 inch deep with alfalfa chaff, and 1,000 weevils were liberated in each car in 10 lots of 100 each, on the floor along its longitudinal axis. After being in



After interval of -	Region number								
	1	2	3	4	5	6	7	8	9
15 days	57.7	13.1	3.9	8.5	0.8	0.8	1.5	4.6	9.2
30 days	38.5	13.1	6.9	11.5	3.1	2.3	2.3	10.0	11.5
60 days	29.2	10.8	3.9	12.3	3.1	3.9	6.2	16.9	13.9

Figure 2.--Distribution of freight cars (130), shown in percentages for the nine regions of the United States indicated on the map.

transit for the number of days indicated in table 4, the chaff was examined, the cracks in the floor cleaned out, and the floor removed in one case and the side walls in another, in order as nearly as possible, to obtain all of the weevils present. The results are given briefly in table 4.

Table 4.--Summary of railway transportation of alfalfa weevils in chaff in empty cars.

Car No.	Duration of trip	Weevils recovered out of 1,000 per car	
		Total	Living
	Days	Percent	Percent
1--	0.25	37.3	32.0
2--	6.08	14.8	11.2
3--	3.09	41.6	35.5

Ninety-four living weevils were obtained from car 3 by removing the floor boards, indicating that, where cracks are present in the floor, the cars cannot be adequately cleaned by sweeping out the chaff. No weevils were obtained by removing the side walls of car 2.

The results obtained for cars 1 and 2 more nearly reflect actual conditions that prevail in empty hay cars than do the results of the third, as the last was a much better car than those ordinarily used for hay. In the case of car 2, the larger floor cracks were filled before the experiment was started and the percentage recovered, 11.2, is probably considerably higher than would normally occur. Thus the best indications from this study are that approximately one-third of the weevils remain alive in an average "hay-class" car during a fourth of a day, while less than 11 per cent remain alive for 6 days. The 1,000 weevils used in each car is 50 to 100 times the average number found under commercial conditions, as indicated in the study of the 130 cars previously referred to. It is therefore probable that relatively few living weevils would remain as long as 1 week in the average hay car when this is transported empty and uncleaned. An examination of the data on the 130 cars studied in 1928 shows that 19, or 14.6 per cent, left the region of origin (region 1) within 7 days after examination. Of these, 13 moved empty into the Pacific Northwest (region 2), 5 into the region extending from southern Wyoming to Omaha (region 9), and 1 into the region comprising Nevada, northern California, and southern Oregon.

Although these additional data suggest that the danger of movement in box cars is not as great as indicated by the data of 1928 taken alone, there is in these figures still abundant evidence of the movement of weevils from one region to another in cars recently used for hay shipment.

It has been pointed out previously that this movement of infested railway cars may be a source of common and general transportation of alfalfa weevils and that, because of the apparent volume of this unrestrained movement, it would tend to render valueless many of the quarantine restrictions placed on the transportation of commodities. On the other hand, the occurrence of weevils in cars used for the shipment of baled alfalfa hay indicates that such hay, at least under some conditions, may be responsible for the movement of a considerable number of weevils. In this connection it should be noted that these cars were examined during the summer and fall period and that most of the hay transported therein, produced under maximum seasonal infestation, undoubtedly contained a much higher infestation than would hay baled and transported during other periods of the year. The summer movement of the alfalfa weevil in empty hay cars into noninfested areas would most favor its establishment and this further emphasizes the importance of this movement as compared with the movement of hay or hay products during the winter, after the heavy mortality in the stacks and bales has occurred.

RESEARCH AS APPLIED TO PROBLEMS OF QUARANTINE

With the primary objective of improving control methods, much information has been accumulated in the last 7 years on the climatic factors controlling the abundance of the weevil. Studies along this line have been conducted in the more heavily infested sections in the center of the infested area, including the States of Utah, Nevada, Idaho, and, more recently, Colorado. The information pertaining to the section around Salt Lake is now practically completed, and this explains to a large degree the factors responsible for periods of high and low population of the weevil in that section, and has established the basic method for this type of research applicable to weevil work in other localities.

In 1932 this method of study was extended to the recently infested area at Medford, Oregon, which presents a very different climatic complex and demonstrates additional applications of the limiting factors to the control of weevil abundance. In addition to supplying information on which cultural-control programs can be based, this type of study furnishes information that will lead to a more definite understanding of the probable geographical limits of weevil spread and that will be of possible significance when scientific quarantine procedures are being formulated.

It is planned to extend this study to the regions of more recent infestation toward the margin of the infested area, with the idea of obtaining information on the climatic limitations present in the areas subject to infrequent outbreaks. It is hoped that information obtained from these localities will afford data of significance as to the probable damage to be expected as the weevil invades new territory.

Experience in predicting probable damage in new territories by other insects does not encourage the belief that the data obtained by this method of study can give an unequivocal answer to questions of distribution. The careful, detailed method of procedure utilized in these studies, however,

can provide a much more positive basis for judgment than any body of information now existing.

The review which has been given of the situation with regard to portable meal mills indicates the desirability of developing definite specifications, if this can be done, for certification of meal mills as safe, provided this possible source of infestation still remains a problem from the quarantine standpoint. The review of the information available on survival in baled hay, given above, indicates the lack of information on this subject, as the data presented were based on only 3 bales the data on only 1 of which are applicable in determining survival of weevils actually in the bales. No information has been obtained on the survival of weevils when the hay is baled during cold weather, the possible mortality in the bale as affected by exposure to warm temperatures in the fall, or--as these studies were conducted on single bales--of the mortality occurring in the baled hay in stacks. These problems deserve further consideration from a research standpoint.

A survey to determine relative abundance and limits of infestation is an expensive procedure and is unsatisfactory so far as determination of freedom from infestation is concerned. To be of value, it must be performed during a relatively short period of time and hence light infestations may readily escape detection. As funds and opportunity permit, however, it would seem desirable to make an occasional check on areas in which the weevil has not been observed recently, reporting the findings in quantitative terms, so that quarantine officers may have data on which to base conclusions regarding the extent of occurrence of the weevil in the various areas.

Scouting around the margins of the infested territory at periodic intervals, in order to detect the development of new infestations, would also appear desirable.

A special effort will be made to obtain additional data on these and other problems that may be suggested.

It must be recognized that quarantine action must frequently precede the accumulation of a body of scientific facts on which it can be based and that delay in action in order to obtain all of the facts might in itself defeat the purpose of the quarantine. The accumulation of facts on which quarantines can be scientifically based, is, however, as truly a function of the research agencies as the development of control methods in areas already infested. It should be no concern of the research worker whether the facts obtained invalidate present procedures, support them, or indicate that modifications are desirable. His primary function is to obtain the facts and to make them available to others. Once the facts are established, it is certainly the function and duty of the agencies responsible for the formulation of quarantines to strengthen, modify, or cancel requirements so that they are in accord with the best available information.